C L A I M S

1. A time-interleaved analog-to-digital converter characterized by comprising:

an input terminal to input a to-be-measured signal;

a signal generator which generates a calibration signal;

a plurality of N analog-to-digital converters;

a switch which selects either of the to-be-measured signal input from the input terminal and the calibration signal output from the signal generator;

a signal divider which divides the signal selected by the switch into a plurality of N components, and causes the plurality of N analog-to-digital converters to input the divided signal components, respectively;

a sampling control unit which assigns sampling clocks whose cycle is Ts and whose phase is shifted by Ts/N, respectively, to the plurality of N analog-to-digital converters;

a correction information memory which stores correction information required to correct an error between signals output by the plurality of N analog-to-digital converters, the error occurring when a difference exists in at least one of a frequency characteristic of an amplitude and a frequency characteristic of a phase from input to the input terminal to a conversion processing in the plurality of

N analog-to-digital converters;

a correction processing unit which carries out a correction processing in accordance with the correction information stored in the correction information memory in response to signals output by the plurality of N analog-to-digital converters to receive the to-be-measured signal; and

a correction information calculating unit which calculates an amplitude and a phase of the plurality of signal components by carrying out a spectrum analysis with respect to signals output by the plurality of N analog-to-digital converters to receive the predetermined calibration signal output from the signal generator, newly obtains the correction information based on a result of the calculation, and updates contents of the correction information memory in accordance with newly obtained correction information,

wherein the signal generator is configured to output the calibration signal that includes a plurality of signal components positioned, respectively, at desired frequencies in a bandwidth in which N/2 times of a frequency Fs of the sampling clock assigned to each of the plurality of analog-to-digital converters is defined as an upper limit, the plurality of signal components appearing at frequencies different from each other in a bandwidth in which half of the frequency Fs of the sample clock is defined as an upper limit by

sampling of each of the analog-to-digital converters.

2. The time-interleaved analog-to-digital converter according to claim 1, characterized in that the signal generator outputs as the calibration signal a pulse signal of which the plurality of signal components in the bandwidth in which N/2 times of the frequency Fs of the sampling clock is defined as an upper limit is composed of a basic wave component and a high harmonic wave component of up to a predetermined order, the pulse signal having a power ratio between overlapped components of a predetermined value or smaller, in the case where a high harmonic wave component that is higher in order than the predetermined order from high harmonic wave components of the pulse signal and the plurality of signal components overlap in a same frequency in the bandwidth in which half of the frequency Fs of the sampling clock is defined as an upper limit by sampling of each of the analog-to-digital converters.

3. The time-interleaved analog-to-digital converter according to claim 1, characterized in that the signal generator is composed of: a plurality of sine wave generators which generate sine wave signals in the bandwidth in which N/2 times of the frequency Fs of the sample clock is defined as an upper limit, the sine wave signals having different frequencies from each other; and an additive combiner which additively

combines output signals of the plurality of sine wave generators with each other.

4. The time-interleaved analog-to-digital converter according to claim 1, characterized in that the correction information calculating unit uses one of the plurality of N analog-to-digital converters as a reference analog-to-digital converter based on the amplitude and phase of the plurality of signal components obtained by the spectrum analysis, and is configured to calculate as the correction information a coefficient of a filter having an impulse response that meets a characteristic of a difference between a frequency characteristic from the input terminal to each of output terminals of the plurality of N analog-to-digital converters and a frequency characteristic of the reference analog-to-digital converter, and to store the calculated coefficient in an AD characteristic table in the correction information memory, and

the correction processing unit includes an estimating device which estimates a sample value obtained assuming that another analog-to-digital converter has made a conversion processing at a timing of updating a sample value by an analog-to-digital converter having received the sampling clock based on each of the sample values output from the plurality of N analog-to-digital converters in response to the to-be-measured signal and the coefficient stored in the AD

characteristic table.

5. The time-interleaved analog-to-digital converter according to claim 4, characterized in that the correction information calculating unit is configured to calculate as the correction information a coefficient of a filter having an impulse response that meets a frequency characteristic of offsetting a difference between a frequency characteristic of the reference analog-to-digital converter and a frequency characteristic of the remainders of the plurality of N analog-to-digital converters, respectively, based on the amplitude and phase of the plurality of signal components obtained by the spectrum analysis, and to store the calculated coefficient in an equalizer coefficient table in the correction information memory, and

the correction processing unit includes a plurality of estimating device, each of which is provided as the estimating device at each of the analog-to-digital converters; and a plurality of equalizers, each of which carries out filtering based on the coefficient stored in the equalizer coefficient table with respect to each of the sample values output by the plurality of estimating devices, and outputs an error-corrected sample value.

6. The time-interleaved analog-to-digital converter according to claim 1, characterized by

further comprising: a plurality of attenuators interposed at least any one of between the input terminal and the switch, between the signal generator and the switch, and between the signal divider and the switch.

7. The time-interleaved analog-to-digital converter according to claim 6, characterized by further comprising: a second switch interlocked with the switch; and a terminator connected to the second switch,

wherein the analog-to-digital converter is configured to, when the calibration signal is selected by the switch, close the second switch and enable the terminator to terminate the to-be-measured signal input from the input terminal.

8. The time-interleaved analog-to-digital converter according to claim 1, characterized by further comprising: signal combining means configured to combine output signals, which are output by the plurality of N analog-to-digital converters to receive the to-be-measured signal through sampling based on the sampling clock, in digital signal sequences arranged in order of sampling, and to output combined output signals.

9. The time-interleaved analog-to-digital converter according to claim 8, characterized by further comprising, as the signal combining means:

an output terminal to output the digital signal sequence; and

a signal switching device which sequentially selectively switches output signals, that are output by the plurality of N analog-to-digital converters to receive the to-be-measured signal through sampling based on the sampling clock, respectively, and which outputs the output signals to the output terminal,

wherein, in order to sequentially selectively switch and output the output signals, that are output by the plurality of N analog-to-digital converters, by means of the signal switching device, the sampling control unit assigns to the signal switching device a specifying signal that specifies an analog-to-digital converter having carried out sampling from among the plurality of N analog-to-digital converters, thereby making it possible to combine signals in digital signal sequences arranged from the signal switching device in order of sampling, and to output combined output signals to the output terminal.

10. The time-interleaved analog-to-digital converter according to claim 9, characterized by further comprising:

a control unit to connect the switch to the signal generator side and input the calibration signal to the signal divider in response to a calibration processing request in accordance with an external instruction or a

predetermined time schedule.

11. A signal processing system characterized by comprising:

a time-interleaved analog-to-digital converter; and

a signal processing device which executes a predetermined signal processing in response to an analog-to-digital converted output signal from the time-interleaved analog-to-digital converter,

the time-interleaved analog-to-digital converter comprising:

an input terminal to input a to-be-measured signal;

a signal generator which generates a calibration signal;

a plurality of N analog-to-digital converters;

a switch which selects either of the to-be-measured signal input from the input terminal and the calibration signal output from the signal generator;

a signal divider which divides the signal selected by the switch into a plurality of N components, and causes the plurality of N analog-to-digital converters to input the divided signal components, respectively;

a sampling control unit which assigns sampling clocks whose cycle is Ts and whose phase is

shifted by Ts/N, respectively, to the plurality of N analog-to-digital converters;

a correction information memory which stores correction information required to correct an error between signals output by the plurality of N analog-to-digital converters, the error occurring when a difference exists in at least one of a frequency characteristic of an amplitude and a frequency characteristic of a phase from input to the input terminal to a conversion processing in the plurality of N analog-to-digital converters;

a correction processing unit which carries out a correction processing in accordance with the correction information stored in the correction information memory in response to signals output by the plurality of N analog-to-digital converters to receive the to-be-measured signal; and

a correction information calculating unit which calculates an amplitude and a phase of the plurality of signal components by carrying out a spectrum analysis with respect to signals output by the plurality of N analog-to-digital converters to receive the predetermined calibration signal output from the signal generator, newly obtains the correction information based on a result of calculation, and updates contents of the correction information memory in accordance with newly obtained correction

information,

wherein the signal generator is configured to output the calibration signal that includes a plurality of signal components positioned, respectively, at desired frequencies in a bandwidth in which N/2 times of a frequency Fs of the sampling clock assigned to each of the plurality of analog-to-digital converters is defined as an upper limit, the plurality of signal components appearing at frequencies different from each other in a bandwidth in which half of the frequency Fs of the sample clock is defined as an upper limit by sampling of each of the analog-to-digital converters.

12. The high speed signal processing system according to claim 11, characterized in that the signal generator of the time-interleaved analog-to-digital converter outputs as the calibration signal a pulse signal of which the plurality of signal components in the bandwidth in which N/2 times of the frequency Fs of the sampling clock is defined as an upper limit is composed of a basic wave component and a high harmonic wave component of up to a predetermined order, the pulse signal having a power ratio between overlapped frequencies a predetermined value or smaller in the case where a high harmonic wave component that is higher in order than the predetermined order from high harmonic wave components of the pulse signal and the plurality of signal components overlap in a same

frequency in the bandwidth in which half of the frequency Fs of the sampling clock is defined as an upper limit by sampling of each of the analog-to-digital converters.

13. The high speed signal processing system according to claim 11, characterized in that the signal generator of the time-interleaved analog-to-digital converter is composed of: a plurality of sine wave generators which generate sine wave signals in the bandwidth in which N/2 times of the frequency Fs of the sample clock is defined as an upper limit and at different frequencies from each other; and an additive combiner which additively combines output signals of the plurality of sine wave generators with each other.

14. The high speed signal processing system according to claim 11, characterized in that the correction information calculating unit of the time interleave scheme analog-to-digital converter uses one of the plurality of N analog-to-digital converters as a reference analog-to-digital converter based on the amplitude and phase of the plurality of signal components obtained by the spectrum analysis, and is configured to calculate as the correction information a coefficient of a filter having an impulse response that meets a characteristic of a difference between a frequency characteristic from the input terminal to each of output terminals of the plurality of N

analog-to-digital converters and a frequency characteristic of the reference analog-to-digital converter, and to store calculated coefficient in an AD characteristic table in the correction information memory, and

the correction processing unit of the analog-to-digital converter includes an estimating device which estimates a sample value obtained assuming that another analog-to-digital converter has made a conversion processing at a timing of updating a sample value by an analog-to-digital converter having received the sampling clock based on each of the sample values output from a plurality of N analog-to-digital converters in response to the to-be-measured signal and the coefficient stored in the AD characteristic table.

15. The high speed signal processing system according to claim 14, characterized in that the correction information calculating unit of the time-interleaved analog-to-digital converter is configured to calculate as the correction information a coefficient of a filter having an impulse response that meets a frequency characteristic of offsetting a difference between a frequency characteristic of the reference analog-to-digital converter and a frequency characteristic of the remainders of the plurality of N analog-to-digital converters, respectively, based on the amplitude and phase of the plurality of signal

components obtained by the spectrum analysis, and to store calculated coefficient in an equalizer coefficient table in the correction information memory, and

the correction processing unit of the time-interleaved analog-to-digital converter includes: a plurality of estimating devices, each of which is provided as the estimating device at each of the analog-to-digital converters; and a plurality of equalizers, each of which carries out filtering based on the coefficient stored in the equalizer coefficient table with respect to each of sample values output by the plurality of estimating devices, and outputs an error-corrected sample value.

16. The high speed signal processing system according to claim 11, characterized in that the time-interleaved analog-to-digital converter further comprises: a plurality of attenuators interposed at least any one of between the input terminal and the switch, between the signal generator and the switch, and between the signal divider and the switch.

17. The high speed signal processing system according to claim 16, characterized in that the time-interleaved analog-to-digital converter further comprises: a second switch interlocked with the switch; and a terminator connected to the second switch, and

the analog-to-digital converter is configured to,

when the calibration signal is selected by the switch, close the second switch and enable the terminator to terminate the to-be-measured signal input from the input terminal.

18. The high speed signal processing system according to claim 11, characterized in that the time-interleaved analog-to-digital converter further comprises: signal combining means configured to combine output signals, which are output by the plurality of N analog-to-digital converters to receive the to-be-measured signal through sampling based on the sampling clock, in digital signal sequences arranged in order of sampling, and to output combined output signals.

19. The high speed signal processing system according to claim 18, characterized in that the signal combining means of the time-interleaved analog-to-digital converter further comprises: an output terminal to output the digital signal sequence; and a signal switching device which sequentially selectively switches output signals, that are output by the plurality of N analog-to-digital converters to receive the to-be-measured signal through sampling based on the sampling clock, and which outputs each of the output signals to the output terminal,

wherein, in order to sequentially selectively switch and output each of the output signals, that are output by the plurality of N analog-to-digital

converters, by means of the signal switching device, the sampling control unit of the time-interleaved analog-to-digital converter assigns to the signal switching device a specifying signal that specifies an analog-to-digital converter having carried out sampling from among the plurality of N analog-to-digital converters, thereby making it possible to combine signals in digital signal sequences arranged from the output signal switching device in order of sampling, and to output combined output signals to the output terminal.

20. The high speed signal processing system according to claim 19, characterized in that the time-interleaved analog-to-digital converter further comprises: a control unit to connect the switch to a side of the signal generator and input the calibration signal to the signal divider in response to a calibration processing request in accordance with an external instruction or a predetermined time schedule.

21. The high speed signal processing system according to claim 11, characterized in that the signal processing device comprises:

a memory which stores analog-to-digital converted output signal output from the time-interleaved analog-to-digital converter;

an analysis processing unit which carries out a predetermined signal analysis processing with respect

to the analog-to-digital converted output signal stored in the memory; and

a system control unit which assigns a calibration processing request to the analog-to-digital converter during a period in which the signal processing device carries out the predetermined signal analysis processing, and causes the analog-to-digital converter to carry out analog-to-digital conversion for the calibration processing, followed by calculation and updating of the correction information and which sets the to-be-measured signal so as to be analog-to-digital convertible with respect to the analog-to-digital converter to receive the end of updating the correction information from the analog-to-digital converter.